

MANURE OVERLOAD ON MARYLAND'S EASTERN SHORE

Phosphorus Regulations Are Needed to Reduce Poultry Pollution into the Chesapeake Bay



ACKNOWLEDGEMENTS

This report was researched and written by Courtney Bernhardt, Eric Schaeffer, Kira Burkhart, Rose Monahan, Jeff Speir, and Tom Pelton of the Environmental Integrity Project. Special thanks to Anne Havemann at the Center for Progressive Reform for submitting numerous public information requests, R. John Dawes, Jr. at Chesapeake Commons for researching and creating maps, and to Daniela Bloch, Tessa Berman, Patton Dycus, and Valerie Baron at the Environmental Integrity Project for help with data processing.

THE ENVIRONMENTAL INTEGRITY PROJECT

The Environmental Integrity Project (EIP) is a nonpartisan, nonprofit organization established in March of 2002 by former EPA enforcement attorneys to advocate for effective enforcement of environmental laws. EIP has three goals: 1) to provide objective analyses of how the failure to enforce or implement environmental laws increases pollution and affects public health; 2) to hold federal and state agencies, as well as individual corporations, accountable for failing to enforce or comply with environmental laws; and 3) to help local communities obtain the protection of environmental laws. Visit our website at <http://www.environmentalintegrity.org>.

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PHOTO CREDIT

Cover stock photo by iStockphoto of a poultry house at an unspecified location. Aerial photos of Concentrated Animal Feeding Operations and picture of manure piled in farm field by Kathy Phillips, Assateague Coastkeeper. Photo on page 6 of manure being spread by Brian Kelly.

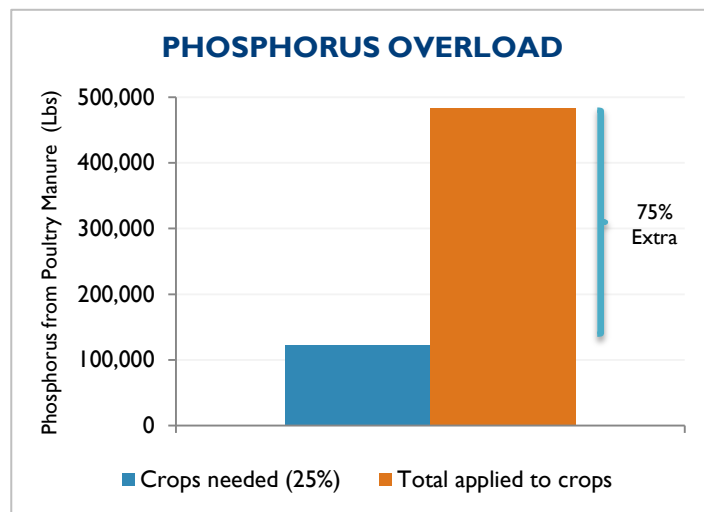
Executive Summary

Poultry farmers spread three times more phosphorus in chicken manure on their fields than their crops needed, according to records from 62 poultry operations in five counties on Maryland's Eastern Shore in 2012.¹ This excessive application of poultry manure is a problem because manure is loaded with phosphorus, and applying it to fields that already have more than enough contributes to phosphorus runoff pollution that feeds algal blooms and low oxygen "dead zones" in the Chesapeake Bay. Approximately 75 percent of the phosphorus in chicken manure applied on these farms was over the amounts needed, and 61 percent of the manure was spread on land that already had "excessive" phosphorus levels, based on criteria published by the Maryland Department of Agriculture.² Because phosphorus was applied in amounts far higher than what crops used, its concentration in soil increased by an estimated 10 percent by the end of the 2012 growing season.³

This analysis by the Environmental Integrity Project is based on field-level data in farm fertilizer management reports called Annual Implementation Reports submitted to the state by 62 poultry operations that spread manure on their own cropland in Caroline, Dorchester, Somerset, Wicomico, and Worcester counties. The data is incomplete, because reports from hundreds of other poultry operations show that about 85 percent of poultry manure is shipped offsite to crop farms and other locations within the Eastern Shore, and crop farms are not required to disclose field-level phosphorus application rates in annual reports.

Missing or incomplete reports are also a problem. Reports were not available for 14 percent of the large poultry operations identified in a Maryland Department of the Environment (MDE) database.⁴ Many of the operators reporting land application of poultry waste did not include soil test data or other information needed to determine phosphorus application rates. Since July of 2014, MDE has sent notices of violation for missing or incomplete reports to 104 of Maryland's 574 animal feeding operations.⁵

As part of Maryland's plan to restore the health of the Chesapeake Bay, Governor Martin O'Malley on November 17 proposed long-delayed manure management regulations designed to target phosphorus "hotspots" on agricultural land and halt over application of manure (or require farms to install additional runoff pollution control practices).⁶ Governor-Elect Larry Hogan has indicated he opposes the new regulations, called the Phosphorus Management Tool.⁷



Source: Maryland Department of Agriculture (MDA) Records

Records from 62 poultry operations in five Eastern Shore counties show that farmers spread 75 percent more phosphorus in chicken manure on their fields than their crops needed in 2012. This land-based disposal of poultry industry waste contributes to the runoff of phosphorus pollution into streams and rivers, feeding algal blooms and "dead zones" in the Chesapeake Bay.

The data in this report show why the Phosphorus Management Tool is so badly needed – and indeed will probably not be enough to reduce the sheer volume of poultry manure applied to Eastern Shore farmland already overloaded with phosphorus. Governor-Elect Hogan should follow through with the rules, strengthen them where possible, and ensure they are enforced for the good of the Chesapeake Bay and the millions of people who rely on this national treasure.

An Analysis of Poultry Operations

The agriculture industry is the single largest source of pollution in the Chesapeake Bay.⁸ Agriculture is responsible for 58 percent of the phosphorus pollution in the Bay and its rivers and streams from Maryland and the other states in the watershed, according to the Environmental Protection Agency.⁹

In moderate amounts, phosphorus feeds the healthy growth of crops on land and algae in waterways. But when applied in excessive quantities, crops and soil cannot absorb all of the nutrient, and rain can wash the surplus phosphorus into streams and rivers. The phosphorus feeds explosive growth of algae that then dies and decays, sucking oxygen out of the water – causing fish kills and stressing blue crabs and other forms of life.¹⁰



A July 2014 analysis by the Environmental Integrity Project of state water quality monitoring data from eight Eastern Shore rivers surrounded by the poultry industry found unhealthy levels of phosphorus from 2003 and 2013.¹¹ Despite claims of progress by the industry in reducing runoff pollution, the data showed no improvement over this decade – and in fact, phosphorus pollution levels increased at monitoring stations in three of the eight rivers (the Nanticoke, the Sassafras, and the Transquaking) during this time period.

This poultry operation on Maryland's Eastern Shore grows millions of chickens a year in long metal buildings. The tons of waste produced by the birds is spread on farm fields.

This report examines exactly how much manure poultry operations are spreading on their fields. Our analysis relies on data from documents called Annual Implementation Reports (AIRs) filed every year with the Maryland Department of Agriculture (MDA) by poultry operations.

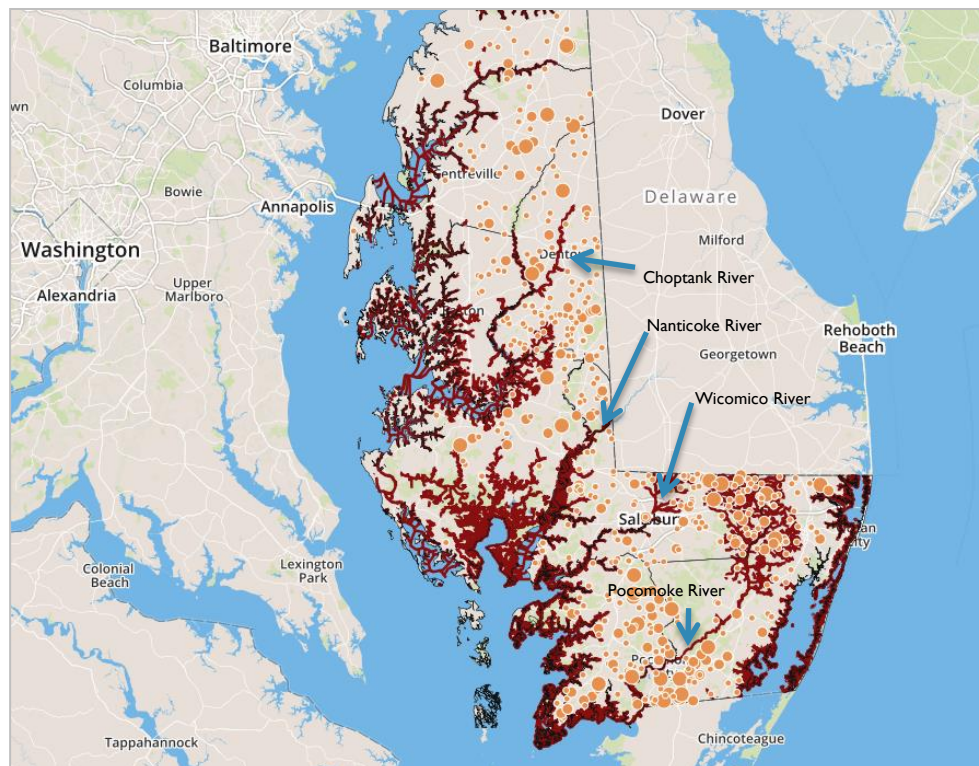
TABLE A: REPORTED POULTRY PRODUCTION IN FIVE EASTERN SHORE COUNTIES

County	Number of Chickens	Number of Poultry Operations
Caroline	37,820,200	84
Dorchester	21,457,450	49
Somerset	47,043,600	74
Wicomico	54,223,200	112
Worcester	57,371,550	85
Total	217,916,000	404

(Source: 2012 Annual Implementation Reports filed by Poultry Operations. The total amount of chickens raised is likely higher due to non-reporting.)

In 2012, 404 poultry operations in Caroline, Dorchester, Somerset, Wicomico and Worcester counties filed these reports with the MDA, which provided them to the Maryland Department of the Environment (MDE). Together, these farms reported raising nearly 218 million chickens in 2012, virtually all of which were produced under contracts with large poultry companies (also called “integrators”) including Perdue, Tyson Foods, Mountaire Farms, Amick Farms, and Allen Harim Foods (Table A). The map below shows the locations of poultry operations (in orange) and waterways (in red) that are so polluted with phosphorus from farms that the rivers and streams are legally designated as “impaired” under the federal Clean Water Act.¹²

LOCATIONS OF POULTRY OPERATIONS AND WATERWAYS IMPAIRED FOR PHOSPHORUS FROM AGRICULTURE¹³



Note: This map shows waterways impaired by phosphorus from agriculture in red. The orange dots indicate poultry operations, scaled by size. Source: Maryland Department of the Environment records.

An online map showing the locations of the poultry operation fields with the highest concentrations of phosphorus in the soil was created by the Center for Progressive Reform and Chesapeake Commons and is available [by clicking here](#).

According to EPA, Eastern Shore waterways have a major impact on water quality in the Bay.¹⁴ Reducing phosphorus loads from these rivers improves oxygen levels in the Chesapeake.¹⁵

While poultry industry representatives have claimed that they are on track to meet their 2017 obligations toward meeting EPA pollution limits for the Chesapeake Bay (also called the Bay Total Maximum Daily Load, or TMDL),¹⁶ the conditions in Eastern Shore rivers show that there is still much more work to be done and that phosphorus hot spots may take a lot of effort to fix.



Manure piled in an Eastern Shore farm field before being spread as fertilizer. Maryland requires poultry farmers to report to the state every year how many chickens they raise, the amount of manure the animals generate, and how much of this manure is applied on the farmer's own fields.

Reporting Requirements

Maryland's Water Quality Improvement Act of 1998 requires most farms to obtain and follow fertilizer and manure management plans, also called Nutrient Management Plans (NMPs). Each year, agricultural operations with NMPs must submit annual implementation reports (AIRs) to the Maryland Department of Agriculture (MDA). MDA created a standardized AIR form on which farmers report information about on-the-ground activities at their farms during the previous calendar year. The annual reports submitted to MDA by concentrated animal feeding operations (CAFOs) and Maryland Animal Feeding Operations (MAFOs) are forwarded to the Maryland Department of the Environment (MDE), which has authority over CAFO and MAFO discharge permits.¹⁷

On their AIRs, both CAFOs and MAFOs are required to provide information about the number and types of animals raised, the amount of manure generated, the amount of manure storage available, the amount of manure imported and exported, whether crops are produced, total crops grown, the number of acres farmed, and amount of nutrients applied by crop.¹⁸ Only CAFOs are required to report field-level nutrient applications to crops, target and actual crop yields, soil phosphorus test results, manure test results, total land application of animal waste, recipients of exported animal waste, and unpermitted discharges.



Poultry manure being spread on a farm field on Maryland's Eastern Shore.

Analysis of the Reports

The Center for Progressive Reform (CPR)¹⁹, a nonprofit organization, filed public information requests to MDE for the 2012 AIRs filed by poultry operations in Caroline, Dorchester, Somerset, Wicomico, and Worcester counties. CPR shared the public records with the Environmental Integrity Project, which recorded the data into a database and analyzed the data using methods outlined in the Maryland Nutrient Management Manual. (For a detailed description of methods and assumptions, see the “Methods” section in the Appendix.)

Poor and incomplete reporting appears to be a problem in Maryland. As a result, the actual amount of manure applied is likely higher than estimated in this report.²⁰ AIRs were not available for 14 percent (58 of 407) of the poultry facilities that were operating in 2012, according to a comparison with the Maryland Department of the Environment animal feeding operation database (see tables 1 and 2 in the Appendix).²¹ The state environmental agency issued violation notices to 104 of Maryland's 574 animal feeding operations from July 1 to October 22, 2014, because the farmers failed to file required reports or filed incomplete reports.²²

Fertility Index Values

Maryland uses a fertility index system to help farmers determine nutrient application rates based on soil test results. Fertility Index Values (FIVs) for phosphorus are calculated using soil test results and formulas contained in the Maryland Nutrient Management Manual.²³ FIVs are interpreted in four categories: low is 0-25; medium is 26-50; optimum is 51-100; and excessive is 100 and higher. Low and medium FIVs tell farmers that crops would grow better with additional phosphorus. Optimum FIVs tell the farmer that existing soil phosphorus is sufficient for plant growth. Excessive FIVs tell farmers that there is already more than enough phosphorus in the soil to meet the needs of most crops.²⁴ The proposed Phosphorus Management Tool would require the farms with fields with the highest FIVs (150 or higher) to limit or halt phosphorus application to those fields. These farms could

also take other steps to reduce pollution, such as planting buffer strips of trees and vegetation along streams. (For an example of how FIVs translate to recommended nutrient application rates, see Table 3 in the Appendix)

Phosphorus Applied to Overloaded Fields

In 2012, 62 poultry operations in the five Eastern Shore counties reported spreading poultry manure containing 481,760 pounds of phosphorus on 10,616 acres of cropland.²⁵ Only 25 percent of that phosphorus was needed to support target crop yields.

Sixty-one percent of the manure was spread on 6,452 acres with Fertility Index Values (FIV) above 100, which means that phosphorus levels were already too high. Forty-three percent of the phosphorus ended up on 4,652 acres with FIVs above 150, a level so excessive it triggers the requirements of the Phosphorus Management Tool (PMT). (See Table B below. For a county-by-county analysis, see Table 4 in the Appendix).

TABLE B: LAND-APPLIED PHOSPHORUS FROM POULTRY MANURE IN FIVE EASTERN SHORE COUNTIES²⁶

	Acres	Phosphorus (lbs)	Percent of Total Phosphorus Applied
Total Phosphorus Applied (lbs)	10,616	481,760	100%
Applied Over Crop Needs	9,271	359,356	75%
Applied to Fields with Excessive Phosphorus (FIV >100)	6,452	293,341	61%
Applied to Fields with Excessive Phosphorus Where the PMT Would Apply (FIV >150)	4,652	204,823	43%

(Source: Annual Implementation Reports filed by the 62 poultry operations that reported land applying poultry manure to their own crops.)

Adding more phosphorus to overloaded fields increases the risk of phosphorus runoff into the Chesapeake Bay and its tributaries. The buildup of phosphorus can be expressed in a simple equation: The amount in the soil at the beginning of the season, plus the amount applied as manure, minus crop nutrient uptake, equals the amount remaining in soil at the end of the season. For example, the manure applied on the 62 farms mentioned above added almost half a million pounds of phosphorus in 2012 to fields that already contained more than 2.43 million pounds of this nutrient.²⁷ The crops only removed about 233,575 pounds of the phosphorus during the growing season.²⁸ The end result (as shown in Table C below) was that 2.68 million pounds of phosphorus were left in the fields at the end of the harvest. That was a ten percent increase in phosphorus soil content above the levels at the beginning of the 2012 growing season. (For a county-by-county analysis, see Table 5 in the Appendix).

TABLE C: ESTIMATED PHOSPHORUS BUILD-UP IN FARM FIELDS DURING 2012

	Phosphorus (lbs)
Available in soil before the growing season	2,430,947
Applied at beginning of the season	487,409
Removed by crops	233,575
Remaining after harvest	2,684,780
Estimated net increase of soil phosphorus after harvest	10%

(Soil phosphorus and applied phosphorus are from AIRs filed by 62 poultry operations in Caroline, Dorchester, Somerset, Wicomico, and Worcester counties in 2012. Crop removal is based on maximum removal rates for crops published by the University of Maryland Extension.)

Most Phosphorus is “Exported” – but stays on the Eastern Shore

Two hundred and eighty three poultry operators reported shipping 175,828 tons of manure to other Eastern Shore locations. That is nearly seven times the amount of manure that was applied onsite by poultry farmers who also grow crops, according to the 2012 reports (Table D). If the manure is sent to a crop farm, Maryland rules do not require disclosure of field-level application rates and soil conditions at the offsite locations receiving this waste.²⁹

TABLE D: ON-SITE LAND APPLICATION AND MANURE EXPORT AT POULTRY OPERATIONS³⁰

County	Manure Land Applied		Manure Exported	
	# Farms/Total	Tons Applied	# Farms/Total	Tons Exported
Caroline	30/84	9,346	56/84	34,689
Dorchester	13/49	4,220	36/49	23,242
Somerset	16/74	4,658	43/74	40,367
Wicomico	8/112	1,981	82/112	41,539
Worcester	15/85	6,135	66/85	36,550
Total	82/402	26,340	283/404	176,387

Note: The number of farms/total represents the number of poultry operations relative to the total number of poultry operations for which AIRs data was available.

Of the poultry operations that exported manure to other locations,³¹ most of the manure was shipped to farms within the same county. Sometimes export destinations appeared to be fields owned or operated by other farmers adjacent to the poultry operation, or just down the road.³² Hardly any poultry operations reported sending their manure to destinations beyond the Eastern Shore.

The table on the next page (Table E) lists the number of destinations to which poultry operations reported sending manure. Most destinations appeared to be farms.³³

TABLE E: MANURE EXPORT DESTINATIONS

County	Addresses receiving manure from poultry operation in same county	Recipient addresses in Lower Eastern Shore ³⁴	Insufficient Information Provided
Caroline	42	25	4
Dorchester	28	86	3
Somerset	13	11	1
Wicomico	35	12	0
Worcester	32	10	1
Total	150	64	9

Some poultry operators reported sending their manure to a fertilizer manufacturer, Perdue AgriRecycle. Perdue AgriRecycle began operating in 2001 in Sussex County, Delaware, and is the region's only facility that converts poultry litter into pelletized fertilizer. Twenty-four farms reported sending all of their manure to Perdue, totaling 16,340 tons of manure that contained approximately 372,552 pounds of phosphorus.³⁵ Fifty-five poultry operations reported exporting their manure to a manure broker, who helps facilitate manure transfers between facilities that have too much manure and those who need it to fertilize their crops (For details, see Table 6 in the Appendix).

Conclusions & Recommendations

Maryland's current regulations are not strong enough to solve the pollution problem caused by decades of over-application of phosphorus from poultry manure on the Eastern Shore. Our analysis of field-specific data showed a significant amount of over-application: 62 poultry operations applied 481,760 pounds of phosphorus to their crops in 2012, with 75 percent of this applied over crop needs. In other words, these farmers spread about three times more phosphorus in manure on their fields than the crops needed – suggesting that the application of much of the litter was really a method of waste disposal for the poultry industry, not an effective use of fertilizer. While the poultry litter may sometimes help meet the nitrogen needs of certain crops, poultry operators will have to find a way to meet those needs – for example, by using nitrogen fertilizer instead of manure – that does not result in phosphorus overload.

To help end this problem, Maryland should implement the proposed Phosphorus Management Tool regulations without delay. Though the proposed rules are weaker than they should be, they are the only option on the table to limit phosphorus applications to land, and ultimately reduce the phosphorus runoff into Eastern Shore waterways and the Chesapeake Bay.

The Maryland Department of Agriculture should improve current reporting requirements to ensure that the data that poultry operators and crop farmers are asked to provide in their Annual Implementation Reports are meaningful and available to other government agencies and the public. More information is needed about what happens to exported manure, and the rates at which it is applied on fields. Based on 2012 reports, about 85 percent of the litter generated by Eastern Shore poultry operations is shipped offsite. Farms that receive this waste and spread it on cropland should be required to submit annual reports that include soil test data and other information needed to determine whether phosphorus is being over-applied. Crop farmers that import poultry waste for use as fertilizer do file annual reports, but these do not include soil test data and other critical information, and the reports and data are not made available to the public. It makes little sense to require phosphorus application data for on-site application of poultry manure, but keep secret the same information from the much larger number of farms that obtain and use this waste from outside sources.

The Maryland General Assembly should act to end this secrecy for the agriculture industry. Without a transparent reporting system, regulators and the public cannot determine whether the state's fertilizer and manure management regulations are resulting in better on-the-ground practices and cleaner waterways.

All residents of the Chesapeake region – including farmers – are hurt by the damage to the Bay caused by the over-application of poultry manure. All of us have an interest in restoring the Bay, which is both an ecological gem and an economic engine. An economic analysis by Salisbury University estimated that the value of the improved water quality that would be created by the proposed Phosphorus Management Tool would be about \$100 million, compared to a cost of \$22.5 million.³⁶ Ultimately, most of the costs of implementing Maryland's phosphorus management regulations should be borne by the big poultry companies that own the chickens and earn most of the profits, not small contract farmers or taxpayers.

NOTES

¹ Based on Annual Implementation Reports filed by 62 poultry operators that applied poultry manure to their own crops in 2012. Reports from more recent years were not available from the Maryland Department of the Environment at the time of our analysis

² Maryland Department of Agriculture. 2012. "Agronomic Crop Nutrient Recommendations Based on Soil Tests and Yield Goals" and "'Plant Nutrient Recommendations Based on Soil Tests for Vegetable Crop Production." In *Maryland Nutrient Management Manual*. Available at: http://mda.maryland.gov/resource_conservation/Documents/nm_manual/I-B1%20p1-15%20update.pdf and http://mda.maryland.gov/resource_conservation/Documents/nm_manual/I-B2%20p1-11%20s6.pdf

³ Based on actual crop yields provided by poultry operators that applied poultry litter to their own crops and maximum regional crop removal rates published by the University of Maryland Extension. (University of Maryland Extension. 2004. "Phosphorus Removal by Crops in the Mid-Atlantic States." Available at: <http://extension.umd.edu/sites/default/files/images/programs/anmp/NM-3.pdf>)

⁴ The Maryland Department of the Environment Animal Feeding Operation database. Available at: <http://www.mde.state.md.us/programs/Land/RecyclingandOperationsprogram/AFO/Pages/CAFO.aspx>

⁵ Timothy Wheeler, "Maryland Chicken Farms Fined for Reporting Lapses," Baltimore Sun, October 22, 2014. Link: <http://www.baltimoresun.com/features/green/blog/bal-maryland-chicken-farms-fined-for-reporting-lapses-20141021-story.html#page=1>

⁶ The proposed regulations are available at: <http://www.dsd.state.md.us/MRegister/4124.pdf>

⁷ Bruce Hotchkiss, "Agriculture industry reacts to election," Delmarva Farmer, November 11, 2014. Available at: <http://www.americanfarm.com/publications/the-delmarva-farmer>

⁸ Maryland BayStat. Available at: <http://baystat.maryland.gov/causes-of-the-problems-map/>

⁹ Chesapeake Bay Program. 2012. "Agriculture." Accessed November 2014. Available at: <http://www.chesapeakebay.net/issues/issue/agriculture#inline>

¹⁰ Chesapeake Bay Program. 2012. "Nutrients." Accessed November 2014. Available at: <http://www.chesapeakebay.net/issues/issue/nutrients#inline>

¹¹ Environmental Integrity Project, "Poultry's Phosphorus Problem: Phosphorus and Algae in Eastern Shore Waterways," July 2014. Available at: <http://environmentalintegrity.org/wp-content/uploads/Poultrys-Phosphorus-Problem.pdf>

¹² MDE's 2012 Integrated Report Water Quality Map: Nutrient Assessments. Accessed November 2014. Available at: <http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Pages/NutrientsAssessmentMap.aspx>

¹³ Map created by Chesapeake Commons. November 2014. Based on farm locations from Maryland Department of the Environment's AFO database (n. 7) and the 2012 Maryland Integrated Report on Water Quality (n. 11)

¹⁴ Linker, Lewis C., Richard A. Batiuk, Gary W. Shenk, and Carl F. Cerco. 2013. "Development of the Chesapeake Bay Watershed Total Maximum Daily Load Allocation." In *The Journal of the American Water Resources Association*. October 2013, Vol. 49, No. 5. Pp. 986-1006.

¹⁵ *Id.*

¹⁶ For example, Bill Satterfield, executive director of the Delmarva Poultry Industry, stated that the poultry industry was exceeding where it needs to be in terms of progress toward phosphorus load reduction goals, in a letter sent to Governor O'Malley on November 13, 2014. Available at: <http://www.dpicken.org/media/docs/20141113173203.pdf>

¹⁷ According to Maryland regulations, a CAFO is a medium or large animal operation that discharges or proposes to discharge to waters of the state. For chicken operations that use dry manure handling, a large animal operation is defined as one that has at least 125,000 chickens or 100,000 square feet of total poultry house capacity. A medium chicken operation has 37,500-124,999 birds and less than 100,000 square feet of total poultry house capacity. In contrast, a MAFO can be either: (1) A large animal operation that does not discharge or propose to discharge to waters of the state; (2) Small or medium animal operations if MDE determines that they are likely to discharge; or (3) chicken (other than laying hens) AFOs with dry manure handling and at least 75,000 square feet of poultry house capacity.

¹⁸ Copies of the 2012 Annual Implementation Reports are on file with EIP and are available upon request..

¹⁹ The Center for Progressive Reform website is <http://progressivereform.org/chesbay.cfm>

²⁰ We excluded land application information from poultry operations that reported spreading an additional 38,617 pounds of phosphorus from manure because they did not provide soil test or crop information.

²¹ There are a few explanations for why reports were not available. First, MDE may not have sent us all the AIRs. Second, MDE may not have received the missing AIRs from MDA. Third, the poultry operator may not have filed their AIR, which is a violation of their operating permit. And fourth, some farms may have changed ownership since 2012 and we were unable to identify those farms.

²² Timothy Wheeler, "Maryland Chicken Farms Fined for Reporting Lapses," Baltimore Sun, October 22, 2014. Link: <http://www.baltimoresun.com/features/green/blog/bal-maryland-chicken-farms-fined-for-reporting-lapses-20141021-story.html#page=1>

²³ See n. 2. Maryland Department of Agriculture. 2006. "Converting Among Soil Test Analyses Frequently Used in Maryland." In *Maryland Nutrient Management Manual*.

http://mda.maryland.gov/resource_conservation/Pages/nm_manual.aspx and AgroLab, Inc. 2011. "FIV Quick Reference Guide." Available at: http://www.agrolab.us/pdfs/FIV_Conversions_ref.pdf.

²⁴ *Id.*

²⁵ Only some poultry operations have land, and of those, some did not report applying manure phosphorus to their crops.

²⁶ Based on information from 62 poultry operations. We excluded manure land-applied to crops when insufficient information was available to determine nutrient recommendations, the total amount applied to all acres, and/or soil FIV categories.

²⁷ This total amount applied is different from the total previously stated because a slightly different set of fields were used to calculate crop removal. The main difference is due the slightly lower amount of information farmers provided about actual crop yields as opposed to target crop yields.

²⁸ See n. 3

²⁹ Maryland rules do not exempt CAFOs that apply manure to their own crops.

³⁰ Not all farms reported land-applying manure or exporting manure. Some farms reported doing both. For the farms that did not report exports or land-application, it is possible that the operation did not remove any poultry litter from their chicken houses and as a result, did not have any manure available to land-apply or send off-site.

³¹ Not all farms that reported exporting manure (in tons) stated where they sent it. Only CAFOs are required to report export destinations, and many operations did not provide this information. CAFOs are also required to state where they plan to send manure in their Comprehensive Nutrient Management Plans.

³² Some farms indicated export addresses that were the same as their poultry operation address.

³³ In some cases, it was not clear if export destinations were farms. Operators are only asked to provide a name and address.

³⁴ Defined here as locations in Caroline, Talbot, Dorchester, Wicomico, Somerset, Worcester, and Sussex (DE) Counties, excluding same-county export destinations. We considered an address incomplete if it lacked the full farm or recipient name or street address and the town in which the recipient was located.

³⁵ Based on a median phosphorus content of manure (22.8 lbs/ton) reported by operators on their 2012 AIRs.

³⁶ Salisbury University Business Economic and Community Outreach Network. November 2014. "A Scenario Analysis of the Potential Costs of Implementing the Phosphorus Management Tool on the Eastern Shore of Maryland." Available at: <http://mda.maryland.gov/Documents/pmt-analysis.pdf>

APPENDIX

Methods

The Environmental Integrity Project's analysis was limited to the information provided by regulated poultry operations on their 2012 Annual Implementation Reports (AIRs). We used methods published in the [Maryland Nutrient Management Manual](#) that were developed by the University of Maryland Extension. While reviewing the AIRs, we found several reporting deficiencies and inconsistencies and did not include incomplete information in our analysis. Additionally, some of the limitations of the data collected on the AIRs required us to make assumptions when necessary. Our methods and assumptions are discussed below.

MANURE EXPORTS

On their AIRs, CAFO and MAFO operators are required to report information about the amount of manure they imported and exported. CAFOs are also required to report where they send their manure, but they are not required to report the amount of manure that they send to each destination or what happens to the manure once it arrives. We compared the amount of manure that was exported to how much was land-applied on-site, examined whether manure exports remained on the Eastern Shore, and determined how many facilities reported recycling some or all of their manure or shipping it using manure brokers. We found the counties that received manure by geo-referencing the export destination addresses provided by operators. Sometimes operators did not provide enough information to determine export addresses.

SOIL PHOSPHORUS LEVELS

Maryland uses an index system to help farmers make decisions about application rates based on soil test results. Most soil test labs use one or two analytical methods to determine soil phosphorus available to plants. Maryland's Nutrient Management Manual, through its fertility indices, takes these soil test results one step further to help farmers determine whether adding additional phosphorus will result in a higher "probability of a favorable economic response" by most crops. These fertility index values, or FIVs, also inform the agronomic nutrient recommendations that farmers use when planning nutrient application rates.

Maryland interprets FIV scores in four categories: low, medium, optimum, and excessive. Low and medium values tell farmers that the soil needs more phosphorus. Optimum values tell the farmer that soil phosphorus is sufficient for crop growth, but the Nutrient Management Manual suggests that they apply some phosphorus anyway. Excessive values tell farmers that no additional phosphorus is needed, and the Nutrient Management Manual does not recommend applying any phosphorus since crops are not likely to respond to it.

On their AIRs, CAFOs are required to report soil test results (in pounds of phosphate per acre or parts per million of phosphate) for the fields to which they

applied manure. Soil test results are supposed to be taken on every field to which manure is applied at least once in every three years. When farmers did not provide the units (lbs/acre or ppm) for their soil test results, we assumed ppm. We converted their soil test results to FIVs using [conversion equations](#) provided in the Nutrient Management Manual.

Some conversion equations required soil test results to be in either ppm or lb/acre. We converted the soil test results from ppm to lb/acre, and vice versa, when necessary. These conversion equations vary depending on the lab and the type of analysis performed by the lab, but poultry operations are not required to report this information on their AIRs. CAFOs are, however, required to report the name of the lab used to analyze their manure samples. Because of the data gaps concerning soil test labs and analysis types, we assumed that farmers used the same lab for both soil and manure samples and that the soil analysis methods were consistent with the methods listed for each lab in the Nutrient Management Manual. Additionally, the Nutrient Management Manual provided two conversion equations for results from A&L Labs. We calculated a range and took the average of estimated FIVs to account for assumptions about lab analysis methods at A&L Labs. Additionally, the Maryland Nutrient Management Manual did not list one lab (AgroLab). For soil tests assumed to be from Agrolab, we used conversion equations provided by Agrolab.

OVER-APPLICATION OF PHOSPHORUS

We sought to answer questions about how much manure was applied, whether farmers were over-applying phosphorus to crops, and if so, were those fields already saturated with phosphorus. We calculated over-application on a field-by-field basis and aggregated the totals by county. We defined over-application as the amount of phosphorus from manure that was applied over the highest nutrient [recommendations](#) in the Nutrient Management Manual. We use recommended rates based on soil tests and target crop yields that we calculated because the recommended rates that operators provided on their AIRs could not be clearly linked to a methodology or source. These nutrient recommendations are based on target crop yields and soil phosphorus FIV categories. We used field-specific crop types and target yields from the AIRs and the FIV categories we determined using soil test results to determine recommended rates. To arrive at the amount over-applied, we compared the amount of phosphorus from manure applied to the amount recommended.

In addition to excess phosphorus application, we estimated how much phosphorus built-up after the 2012 growing season based on actual crop yields. Farmers apply nutrients based on how much of a crop they aim to grow, called a target yield. Our analysis was based on actual yields, or the amount of a crop that farmers reported harvesting in 2012. Droughts, floods, and other unforeseen circumstances can result in lost crop yields. The purpose of this analysis was to determine how much phosphorus was added to the soil by the end of the 2012 growing season. Soil phosphorus did not increase on all fields, and it increased on some fields more than others.

We relied on crop types, actual yields, soil test results, and applied manure phosphorus from the AIRs. We used average regional crop [phosphorus removal rates](#) published by the University of Maryland Extension to estimate the amount of phosphorus removed by crops. Crop removal rates refer to the amount of the phosphorus found in crops at the time they are harvested. Removal rates do not include root matter or other debris. This material that was not harvested remains on the field, and the nutrients they absorbed from the soil are not removed from the field.

Tables

TABLE 1: NUMBER OF POULTRY FARMS

	2012 AIRs	MDE Database ¹
Caroline	84	95
Dorchester	49	41
Somerset	74	72
Wicomico	112	110
Worcester	85	89
Total	404	407

¹As of November 2014. We excluded poultry operations listed in MDE's database of Animal Feeding Operations that filed Notices of Intent after 2012.

TABLE 2: MISSING AIRS AND MISSING FARMS

	Farms listed on MDE's AFO database but we do not have their 2012 AIRs		Farms for which we have their 2012 AIRs but were not listed in MDE's AFO database	
Caroline	18/95	19%	7/84	8%
Dorchester	10/41	24%	18/49	37%
Somerset	12/72	17%	11/74	15%
Wicomico	12/110	11%	9/112	8%
Worcester	6/89	7%	10/85	12%
Total	58/407	14%	55/404	14%

TABLE 3: CATEGORIES FOR PHOSPHORUS FIV SCORES AND RECOMMENDED AGRONOMIC PHOSPHATE APPLICATION RATES FOR CORN GRAIN

Category	FIV-P	Phosphorus Level	Total recommended application rate for corn grain (lbs Phosphate/acre) ¹
Low	0-25	Deficient for crop growth	65-135
Medium	26-50	Might be deficient for crop growth	30-65
Optimum	50-100	Adequate for crop growth	20-30
Excessive	> 100	More than adequate for crop growth	0

¹ Assuming a target yield of 140 bushels per acre and conventional tilling.

TABLE 4: FIELD-SPECIFIC LAND APPLICATION OF PHOSPHORUS FROM POULTRY MANURE, BY COUNTY^a

	Caroline	Dorchester	Somerset	Wicomico	Worcester	Total
Number of Farms Reporting	18/84	10/49	14/74	7/112	13/85	62/404
Total Phosphorus Applied (lbs)	100,055	66,626	101,646	39,765	173,668	481,760
Applied Over MDA Nutrient Recommendations (% of total applied)	52,046 (52%)	49,367 (74%)	95,823 (94%)	38,319 (96%)	123,801 (71%)	359,356 (75%)
Applied to Fields with Excessive Phosphorus (% of total applied)	39,250 (39%)	41,402 (62%)	91,969 (90%)	37,336 (94%)	83,384 (48%)	293,341 (61%)
Applied to Fields Where the PMT Would Apply (% of total applied) ³	10,361 (10%)	32,935 (49%)	81,051 (80%)	23,151 (58%)	57,325 (33%)	204,823 (43%)

^a Based on field-specific data provided by 62 poultry operations for the 2012 operating year. The total amount of phosphorus that poultry operations reported applying, on the field-level, is actually greater because we excluded data from our analysis due to missing information and poor reporting. Specifically, we did not include information for fields that farmers reported applying an additional 38,617 pounds of phosphorus because farmers did not also report target yields, crop types, and/or soil test results. We also excluded phosphorus information for fields if poultry operators did not report total field acreage. Poultry operators that did not provide field acreage reported applying manure phosphorus at rates between 26 and 86 pounds per acre on 53 fields in Worcester and Caroline Counties. 16 of those fields had excessive soil phosphorus levels.

TABLE 5: SOIL PHOSPHORUS BUILDUP AFTER 2012 HARVEST, BY COUNTY

	Caroline	Dorchester	Somerset	Wicomico	Worcester	Total
Available in soil before the growing season	366,837	237,334	704,914	167,106	954,756	2,430,947
Applied at start of growing season	106,347	66,626	101,003	39,765	173,668	487,409
Removed by crops	34,748	44,465	46,060	16,256	92,046	233,575
Remaining after harvest	438,437	259,495	759,856	190,615	1,036,377	2,684,780
% Increase of soil phosphorus after harvest	20%	9%	8%	14%	7%	10%

TABLE 6: FARMS THAT RECYCLED MANURE OR SHIPPED IT USING A MANURE BROKER

County	Number of farms exporting to Perdue AgriRecycle	Number of farms exporting manure brokers
Caroline	2	0
Dorchester	2	1
Somerset	6	17
Wicomico	18	24
Worcester	7	13
Total	35	55



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